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(71) Applicant

**Crystalate Electronics Limited**

**(Incorporated in United Kingdom)**

**Wharf House, Medway Wharf Road, Tonbridge,  
Kent, TN9 1RE**

(72) Inventor

**Duncan George Brodie**

(74) Agent and/or Address for Service

**Welwyn Electronics  
Bedlington, Northumberland, NE22 7AA**

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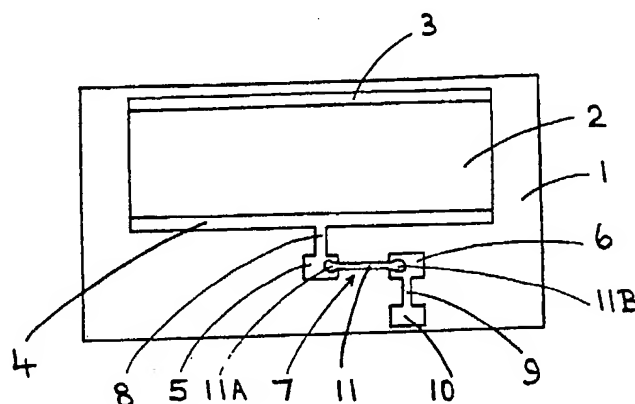
**H2G**

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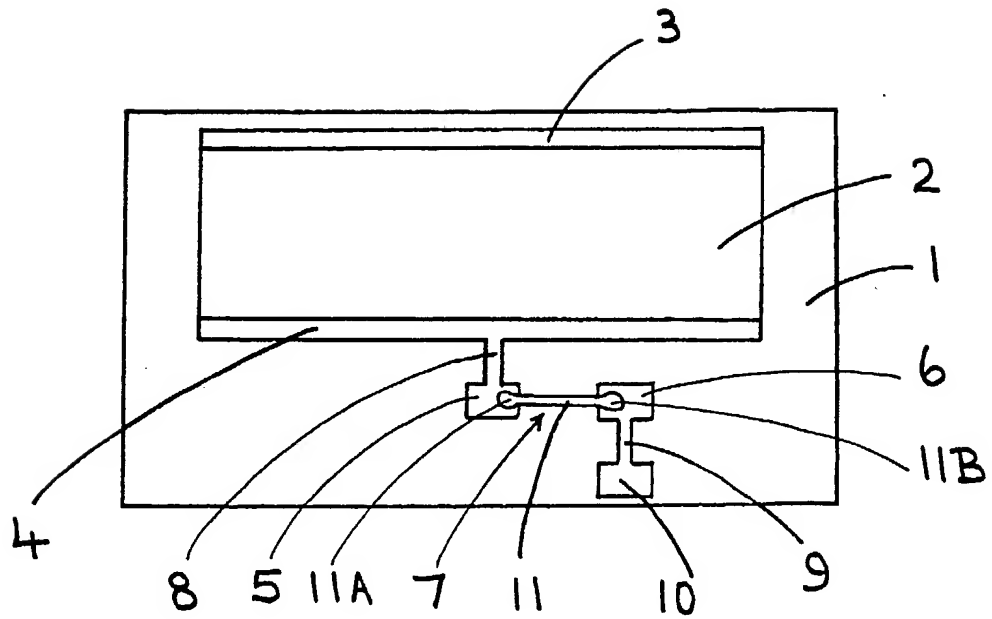
## (54) Thermal fuse

(57) A thermal fuse comprises a substrate (1), suitably of ceramic material, with a pair of tinned film conductors (5, 6) provided thereon with a gap (7) between them. A short electrically conducting wire (11), (eg 5mm long) of a solder alloy is located across the gap (7) with opposite ends, (11A, 11b) of the wire in contact with the conductors (5, 6). The ends (11A, 11B) of the wire (11) are heat-fused to the conductors (5, 6) while the substrate (1) is heated, but surprisingly, without damaging the wire (11). A film resistance element (2) with terminations (3) and (4) is also provided on the substrate (1), electrically connected in series with the wire (11). If the resistance element (2) overheats as a result of an electrical overload in a circuit in which the assembly is connected the wire (11) melts and withdraws onto the conductors (5, 6) thereby breaking the circuit.



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THERMAL FUSE

This invention relates to thermal fuses for use as protective devices to break electrical circuits when a predetermined temperature is reached. The invention is particularly, although not exclusively, applicable to thermal fuses for connection in circuit with film resistors and operating to break the circuit if the temperature of the resistors becomes excessive as a result of electrical overload.

It is known to provide a film resistance element on a flat or cylindrical ceramic substrate and to deposit on the substrate, in series with the resistance element, a fusible layer which melts at a pre-selected temperature to open-circuit the resistor. The fusible layer is formed by plating a material such as cadmium onto a film of sensitising material such as silver.

It is also known to provide a thermal fuse for interconnection electrically and in thermal communication with an electrical resistor in which a fuse link comprises a strip of gold, or optionally silver, deposited as a thick film paste between electrodes and then fired. A layer of solder paste is then deposited overlying the fuse link. In operation, if the resistor overheats, the solder paste melts and leaches the fuse link and separates into globules on the electrodes.

The above prior art techniques are complex and inconvenient in that they require deposition of multiple layers of material to form a fuse. It has also been proposed to provide a thermal fuse connected in series with a film electrical resistance element on a planar substrate in which a fuse link comprising a wire of a solder alloy is mechanically crimped at its ends to metal terminals secured to an edge of the substrate. The metal terminals were also considered to be necessary to serve as heat sinks to enable heat to be applied from a soldering iron momentarily to the ends of the fuse link to fuse the ends of the link to the terminals to ensure reliable electrical connection, without detriment to the fuse link between the terminals. This arrangement is disadvantageous in that not only does it require the provision of specially formed metal terminals but the fuse link is spaced from the substrate so that it is not in optimum thermal contact with the substrate and a resistance element deposited thereon.

It is an object of the present invention to provide a simplified and economical thermal fuse arrangement and a method of its manufacture.

The present invention provides a thermal fuse comprising: a substrate of electrically insulating material; a pair of electrical conductors of film form deposited on the substrate and having a gap therebetween; an electrically conducting wire of a solder alloy located across said gap with opposite ends of said wire in electrical contact with said conductors said ends of said wire having been heat-fused to said conductors.

The present invention also provides a method of manufacturing a thermal fuse comprising: providing a substrate of electrically insulating material; depositing a pair of electrical conductors of film form on the substrate with a gap therebetween; locating an electrically conducting wire of a solder alloy across said gap with opposite ends of said wire in contact with said conductors; and securing and electrically connecting said ends of said wire to said conductors by heat-fusion of said ends of said wire.

It is self-evident that the said electrical conductors are formed of a solderable material.

Preferably the said electrical conductors are tinned to facilitate the heat-fusion of the ends of the wire of solder alloy thereto. Tinning of the conductors is preferably effected with a solder alloy of substantially the same composition as that of the said wire.

Preferably the substrate is heated while the ends of the wire of solder alloy are being heat-fused to conductors thereon. This heating of the substrate should be to a temperature less than the melting point of the wire.

The composition of the wire of solder alloy is selected according to the temperature at which the wire is required to melt for operation of the fuse. A large range of solder alloys is commercially available in wire form. Examples of some such alloys are as follows.

1. An alloy comprising 63% of tin and 37% of lead, having a melting point of  $183^{\circ}\text{C}$
2. An alloy comprising 96% of tin and 4% of silver, having a melting point of  $221^{\circ}\text{C}$
3. An alloy comprising 5% of tin, 93.5% of lead and 1.5% of silver, having a melting point of  $300^{\circ}\text{C}$

The above three solder alloys are available from Multicore Solders Ltd, having product references SN63, SN96 and HMP respectively.

The thermal fuse of the invention operates as follows. When subjected to heat such that the melting point of the solder alloy is exceeded, the wire of solder alloy melts and withdraws onto the conductors, thereby breaking an electrical circuit in which the fuse is connected.

The wire of solder alloy may suitably incorporate a core of flux to assist withdrawal onto the conductors when the alloy melts during operation of the fuse.

The said substrate of said fuse may also have a film electrical resistor supported thereon, in thermo-conducting relationship with and electrically connected in series with said fuse.

It is surprising that the present invention is successful. It relies on the brief application of heat to the ends of the wire of solder alloy to cause the ends of the wire to melt so that on cooling they become electrically connected and bonded to the conductors on the substrate. It would be expected that during the application of heat, which is conveniently provided by means of a soldering iron, the wire would quickly melt along its entire length. This would be thought to be particularly so since the wire is generally required to be short, eg about 5mm in length. In practice, however, it has been found that the ends of the wire can be locally melted without difficulty to effect the necessary bonding. The process is further facilitated by heating the substrate as referred to above.

The invention is now described by way of example with reference to the accompanying drawing which represents a plan view of a thermal fuse of the invention having a film electrical resistor.

A planar ceramic substrate 1 is provided, suitably comprising 96% alumina. A thick film resistance element 2 is deposited on the substrate 1, using well-known screen-printing and firing techniques, and is provided at opposite sides thereof with electrically conducting terminations 3 and 4, also of film form and comprising, for example, palladium-silver. The conducting terminations 3 and 4 are formed using well-known screen printing and firing techniques. An example of a suitable material used to form the terminations is Du Pont 9308 palladium-silver composition. A pair of conductors 5 and 6, with a gap 7 therebetween is also provided on the substrate 1. Conductor 5 is electrically connected by a link 8 to termination 4 of the resistance element 2 and conductor 6 is electrically connected by a link 9 to a conducting termination 10. The conductors 5 and 6, the termination 10 and the links 8 and 9 all suitably comprise palladium-silver and are formed simultaneously with the terminations 3, 4 of the resistance element 2. The conductors 5, 6 are then tinned with a solder alloy and an electrically conducting wire 11 of a solder alloy is located on the substrate 1 across the gap 7 with opposite ends 11A, 11B of the wire in contact with the tinned conductors 5 and 6. The solder alloy used for tinning the conductors 5, 6 preferably has a composition substantially the same as the wire 11. The substrate 1 is heated to a temperature of about 40 to 50°C below the melting point of the wire 11 and a heated soldering iron is briefly applied in turn to the ends 11A, 11B of the wire 11. Local melting of the wire 11 occurs at the ends thereof and after removing the iron the ends 11A, 11B of the wire 11 become bonded and electrically connected to the conductors 5 and 6. This heat-fusion of the ends of the wire 11 to the conductors 5 and 6 takes place, somewhat surprisingly, without affecting the remainder of the wire 11, particularly since the overall length of the wire 11 may for some applications only be of the order of a few millimetres (eg 5 millimetres). The wire 11 is to serve as a thermal fuse link. It is therefore selected according to the temperature required for it to melt to break electrical continuity between terminations 3 and 10 in event that the temperature of resistance element 2 rises excessively as a result of electrical overload. If, for example, it is required for the wire 11 to melt when the temperature reaches 183°C, a wire having a composition of 63% of tin and 37% of lead is suitable. Such a wire is available from Multicore Solders Ltd, having reference SN63. The resulting assembly is connected to an external circuit (not shown) by way

of terminations 3 and 10. If during operation a fault condition arises and an overload is experienced by the resistance element 2, the temperature of the resistance element 2 rises. Heat is conducted to the wire 11 of the fuse and when the temperature reaches the melting point of the solder alloy of the wire 11, the wire melts and withdraws onto the conductors 5 and 6. The circuit is thereby broken. The presence of one or more cores of flux in the solder alloy of the wire 11 assists the withdrawal of the molten material of the alloy onto the conductors 5 and 6.

Although the foregoing example illustrates the use of the fuse of the invention in combination with an electrical resistor, the invention is not limited to such application. The fuse of the invention may be applied wherever it is required for a circuit to be interrupted when an excessive rise in temperature occurs.

CLAIMS

1. A thermal fuse comprising: a substrate of electrically insulating material; a pair of electrical conductors of film form deposited on the substrate and having a gap therebetween; an electrically conducting wire of a solder alloy located across said gap with opposite ends of said wire in electrical contact with said conductors said ends of said wire having been heat-fused to said conductors.
2. A thermal fuse according to Claim 1 in which the said electrical conductors are tinned to facilitate the heat-fusion of the ends of the wire of solder alloy thereto.
3. A thermal fuse according to Claim 2 in which the tinning on the conductors comprises a solder alloy of substantially the same composition as that of the said wire.
4. A thermal fuse according to Claim 1, 2 or 3, in which the composition of the wire of solder alloy is selected according to the temperature at which the wire is required to melt for operation of the fuse.
5. A thermal fuse according to any preceding Claim which when connected in an electrical circuit and subjected to heat such that the melting point of the solder alloy is exceeded, the wire of solder alloy melts and withdraws onto the conductors, thereby breaking the electrical circuit.
6. A thermal fuse according to Claim 5 in which the wire of solder alloy incorporates a core of flux to assist withdrawal onto the conductors when the alloy melts during operation of the fuse.
7. A thermal fuse according to any preceding Claim in which the said substrate of said fuse also has a film electrical resistor supported thereon, in thermo-conducting relationship with and electrically connected in series with said fuse.
8. A thermal fuse constructed and arranged substantially as hereinbefore described with reference to the accompanying drawing.
9. A method of manufacturing a thermal fuse comprising: providing a substrate of electrically insulating material; depositing a pair of

electrical conductors of film form on the substrate with a gap therebetween; locating an electrically conducting wire of a solder alloy across said gap with opposite ends of said wire in contact with said conductors; and securing and electrically connecting said ends of said wire to said conductors by heat-fusion of said ends of said wire.

10. A method according to Claim 9 in which the said electrical conductors are tinned to facilitate the heat-fusion of the ends of the wire of solder alloy thereto.
11. A method according to Claim 10 in which tinning of the conductors is effected with a solder alloy of substantially the same composition as that of the said wire.
12. A method according to Claim 9, 10, or 11 in which the substrate is heated while the ends of the wire of solder alloy are being heat-fused to conductors thereon.
13. A method according to Claim 12 in which heating of the substrate is to a temperature less than the melting point of the wire.
14. A method according to any of Claims 9 to 13 in which the composition of the wire of solder alloy is selected according to the temperature at which the wire is required to melt for operation of the fuse.
15. A method according to any of Claims 9 to 14 in which the wire of solder alloy incorporates a core of flux to assist withdrawal of the alloy onto the conductors when the alloy melts during operation of the fuse.
16. A method according to any of Claims 9 to 15 in which the said substrate of said fuse also has a film electrical resistor supported thereon, in thermo-conducting relationship with and electrically connected in series with said fuse.
17. A method of manufacturing a thermal fuse substantially as hereinbefore described with reference to the the accompanying drawing.
18. A thermal fuse whenever produced by the method of Claims 9 to 17.